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STUDIES ABOUT AVAILABILITY OF Pu ADN Am IN SOILS  
FOR PLANT UPTAKE BY ROOT

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## STUDIES ABOUT AVAILABILITY OF Pu AND Am IN SOILS FOR PLANT UPTAKE BY ROOT

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### 1. INTRODUCTION

The availability for absorption through the roots of plants, of the elements present in the soil, basically depends on the chemical form and, therefore, on the geochemical associations which these elements have in the soil.

In order to gain further knowledge of the geochemical associations that Pu and Am show in the soil, a sequential leaching method has been applied to an accidentally contaminated soil from the Palomares area (Almería-Spain), where a nuclear accident occurred twenty six years ago.

The method employed is basically McLaren and Crawford, used by Iu et al. and modified by Cook, Livens and Baxter, applying modifications brought in by our work group (table 1).

These modifications have basically been:

1. The inclusion of a prior extraction stage with

distilled water, whereby the fraction of the water soluble radionuclide is obtained.

2. Differentiation between the residual fraction radionuclide extracted directly with  $\text{HNO}_3$  7.8N, and that obtained with a hot  $\text{HNO}_3$  12M / HF 1M mixture.

3. Calculation of the optimum permanence time with the solid for each reagent.

4. Inclusion of a weight correction of the sample when beginning each extraction stage, this allows us to maintain the established volume/weight ratios.

#### 2.1. OPTIMUM EXTRACTION TIME

In order to establish the optimum permanence time that would allow maximum extraction with each reagent, the following experiment was performed:

The method was applied with an extraction time of 200 hours for each reagent, withdrawing aliquots of 2 ml which, after being filtered through a  $0.45\mu\text{m}$  filter and evaporated, were measured in a continuous gas-flow meter.

The figures 1a, 1b, 1c, 1d, 1e and 1f show the activities of the solutions in view of the time in which the aliquots have been extracted, which gives us an idea of how extraction varies with time. In addition they have served to give the optimum extraction time ( $T_0$ ) for each reagent.

We consider the optimum extraction time when there is no increase in the activity extracted with the passing of

time.

A note worthy point is the reduction in the activity extracted with the passing of time in the case of distilled water. This fact may be due to the formation of colloids of a size greater than  $0.45\mu\text{m}$  which would be retained while the aliquots are being filtered.

## 2.2. PROCEDURE

The procedure was carried out in seven consecutive stages using two samples of the same soil, each weighing five grams. The soil activity for Pu-239 is  $1727 \pm 180$  Bq/gr and for Am-241 is  $223 \pm 25$  Bq/gr. Pu-239/Pu-238 ratio is around 54.

## 3. RESULTS

### 3.1. Plutonium distribution

The results obtained on Pu-239 + Pu-240 in the different soil fractions are shown in figure number 2.

The greatest mobility stage of Pu-239 + Pu-240, made up of the soluble, exchangeable and inorganically adsorbed fractions, represents 0.2 per cent of the total Pu-239 + Pu-240 extracted.

Associated to organic matter we have 6 per cent of the total Pu-239 + Pu-240, and approximately the remaining 93 per cent is associated to sesquioxides and distributed between the two residual fractions.

The Pu-238 distribution does not vary substantially from that of the Pu-239 (figure 3), except in the soluble and interchangeable fractions where the Pu-238 percentage is around three times the Pu-239 percentage, which brings about a variation in the Pu-239/Pu-238 ratio (table 2). This fact is related to the physiological behaviour of these radionuclides.

### 3.2. Americium Distribution

As far as the distribution of Am is concerned, approximately 63 per cent of the Am-241 extracted is found in the greatest mobility phase, made up of the soluble, exchangeable and inorganically-adsorbed fractions (see fig. 4).

1.3 per cent is linked to organic matter, while approximately 16 per cent of the Am-241 extracted is coprecipitated with oxides and sesquioxides.

Finally, 20 per cent of the americium is found in the residual phase.

## 4. CONCLUSIONS

- \* Approximately 93 per cent of the activity concentration of Pu-239 + Pu-240 is found to be associated with sesquioxides and distributed between the two residual fractions.
- \* The Pu-238 distribution does not vary substantially from that of the Pu-239, except in the soluble and exchangeable

fractions, where the percentage of Pu-238 is around three times the Pu-239 percentage.

\* Approximately 63 per cent of the Am extracted is found in the greatest mobility phase, made up of the soluble, exchangeable and inorganically-adsorbed fractions.

\* The greatest mobility phase of the americium is much higher than the greatest mobility phase of the plutonium.

\* The formation of colloids may occur during extraction, and therefore, there is a possible dynamic equilibrium between the solid, soluble and colloidal phases of the system.

5. FIGURES AND TABLES

FIG. 1a

EXTRACTION WITH DISTILLED WATER

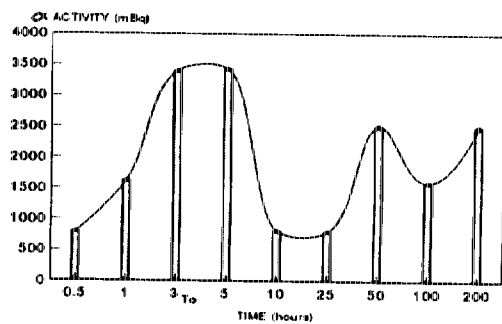


FIG. 1b

EXTRACTION WITH  $\text{CaCl}_2 0.05\text{M}$

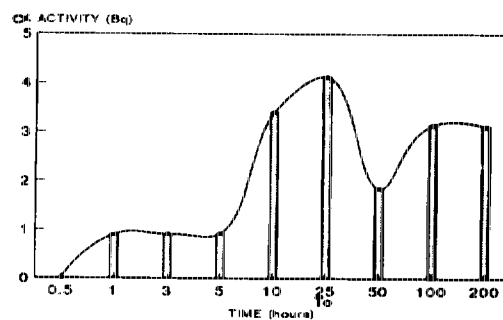


FIG. 1c

EXTRACTION WITH ACETIC ACID 0.5M

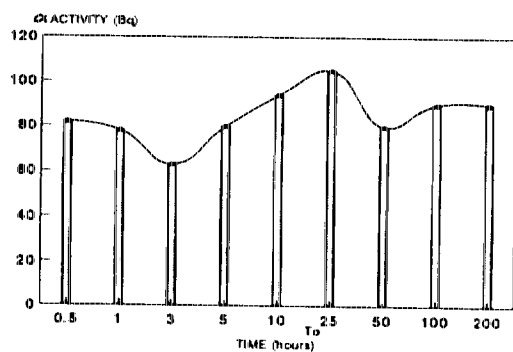


FIG. 1d

EXTRACTION WITH SODIC PIROPHOSFATE 0.1M

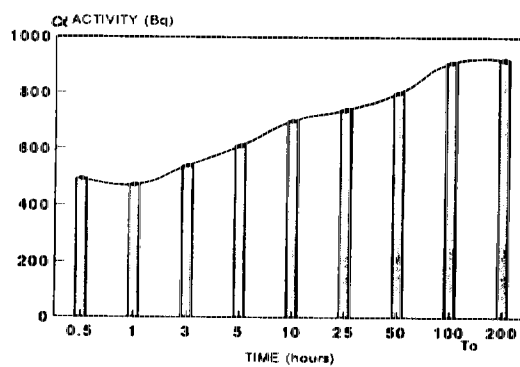


FIG. 1e

EXTRACTION WITH AMONIUM OXALATE 0.175M

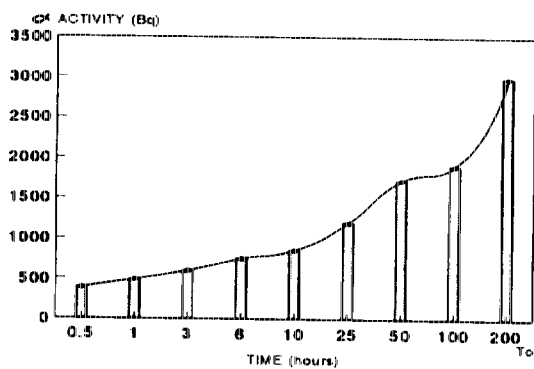


FIG. 1f

EXTRACTION WITH NITRIC ACID 7.8M

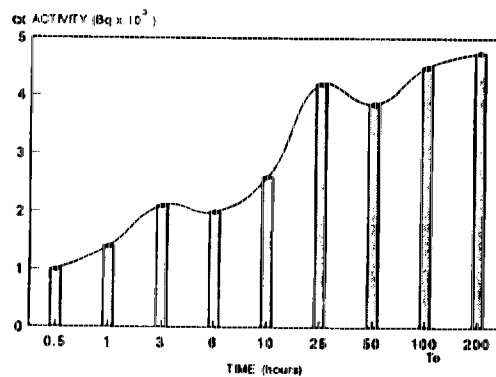


Figure 2

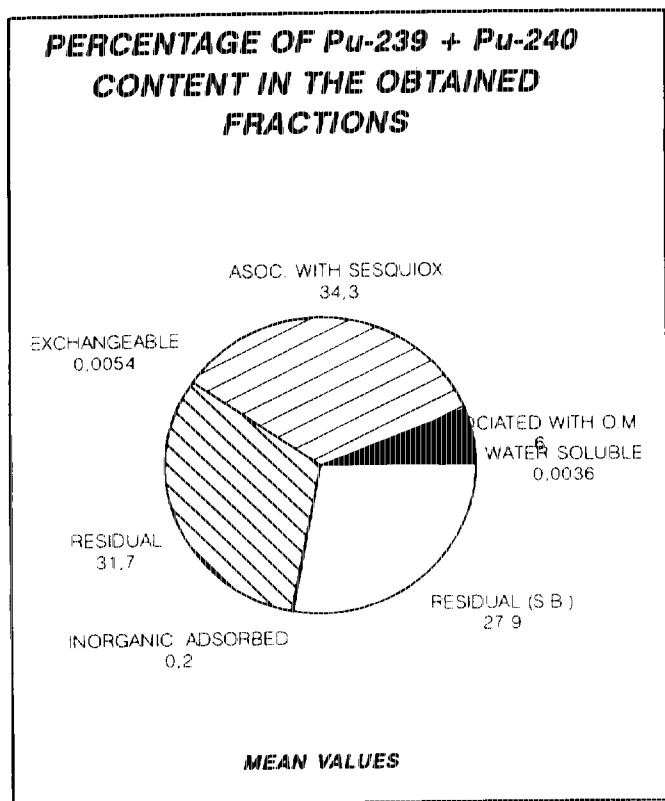


Figure 3

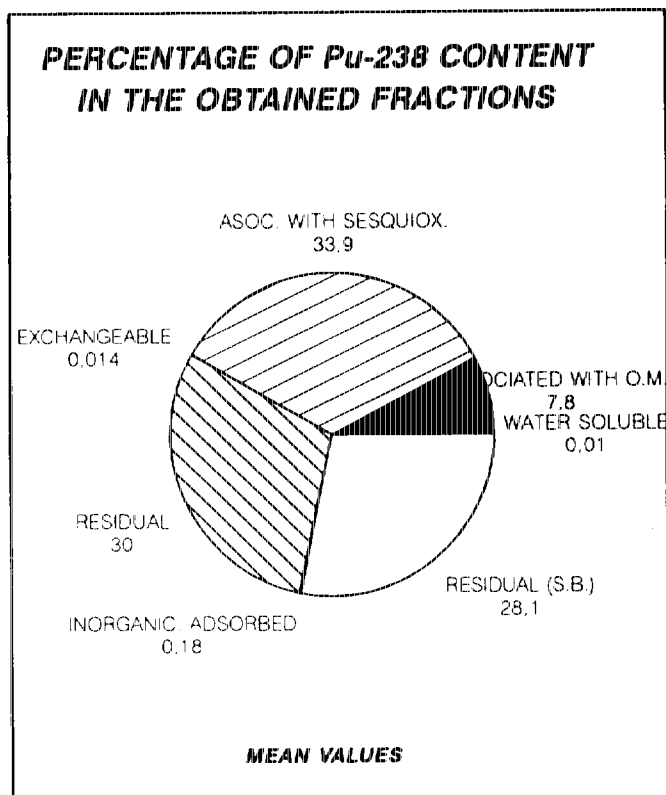


Figure 4

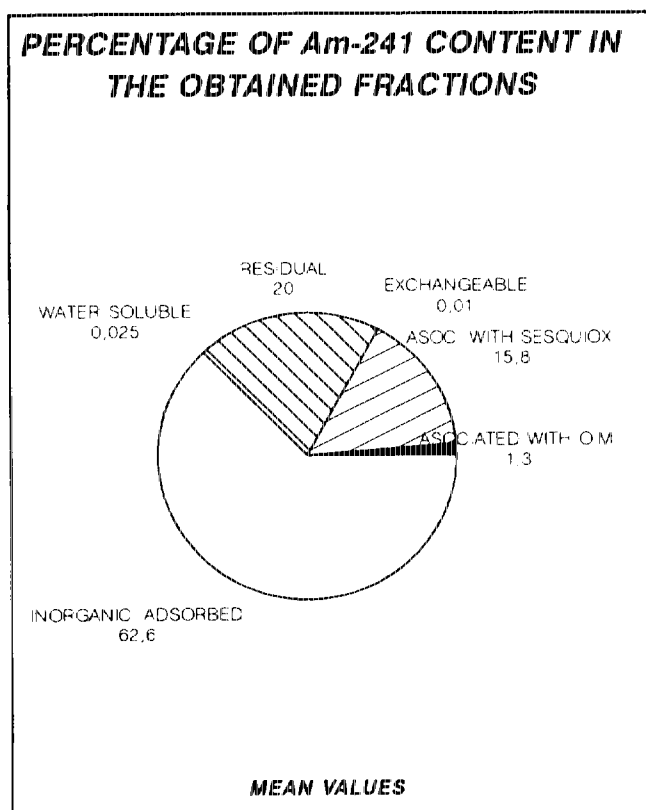


Table 1.

SEQUENTIAL LEACHING METHODOLOGY  
APPLIED IN THIS WORK

<u>FRACTION</u>	<u>REAGENT</u>	<u>VOLUME (ml/gr)</u>
WATER SOLUBLE	DISTILLED WATER	20
EXCHANGEABLE	0.05M $\text{CaCl}_2$	20
SPECIFICALLY ADSORBED	0.5M ACETIC ACID	20
ORGANICALLY BOUND	0.1M $\text{Na}_4\text{P}_2\text{O}_7$	100
OXIDE BOUND	0.175M $(\text{CO}_2\text{NH})_2$ 0.1M $(\text{CO}_2\text{H})_2$	75
RESIDUAL	7.8M $\text{HNO}_3$	70
RESIDUAL (STRONGLY BOUNDED)	HF + $\text{HNO}_3$	70

Table\_2.

*(Pu-239 + Pu-240)/Pu-238*  
**RATIOS**  
*IN THE OBTAINED FRACTIONS*

<u>FRACTION</u>	<u>RATIO</u>
WATER SOLUBLE	19
EXCHANGEABLE	22
INORG. ADSORBED	55
ASOCIATED WITH O.M.	50
ASOCIATED WITH SESQUIOX.	55
RESIDUAL	58
RESIDUAL (S.B.)	54

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